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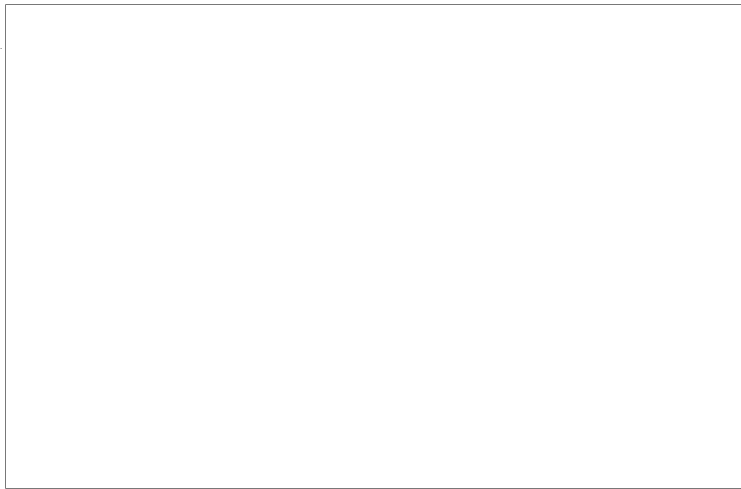


THE ABSORPTION OF ULTRASONIC VIBRATIONS
IN RUBBER

L. A. Shinyanskii

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(From Russian)

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The coefficients of linear absorption α of ultrasonic vibrations in different types of rubber have been measured and the dependence of α on deformation, type of filler and vulcanisation process has been determined.

Measurements were carried out at room temperature ($16^\circ - 18^\circ\text{C}$) and frequency of 3250 kcs.

The application of ultrasonic vibrations to the investigation of the properties of rubber was first reported in an article by MALOV and PZHEVKIN [1]*.

The authors, investigating the sound-insulating capabilities of rubber materials at an ultrasonic frequency of 573 kcs measured the "sound-insulation" of rubber

$$Z_2 = 10 \lg \frac{W_1}{W_3},$$

where $\frac{W_1}{W_3}$ is the ratio of the energy of sonic waves, passing from medium 1 to medium 3 by propagation of the waves in medium 2.

In subsequent years ultrasonic methods found wide application in research on the properties of rubber [2 - 9].

The most important problems of rubber technology are concerned with the production of different grades with given properties.

The solution of such problems is facilitated if these properties correspond to certain easily determined physical constants.

The coefficient of linear absorption α may serve as one of these values.

A relatively simple method [10] was used for the measurement of α of rubber.

The value α is calculated from

$$I = I_0 e^{-2\alpha l} \quad \dots\dots (1)$$

where I_0 = the intensity of the incident ultrasonic waves with $l = 0$; I is the intensity of the ultrasonic waves for a thickness l of the specimen.

For a number of cases α is determined from the slope of the curve [10]

$$\ln I = \ln I_0 - 2\alpha l,$$

plotted on a system of co-ordinates, along the axes of which the values $\ln I$ and l for different thickness of one type of rubber have been measured.

In every case the values of α , calculated from (1) and also from the graph have given good agreement.

The compositions of the tested rubbers are given in the table together with the value of the coefficient of linear absorption which varies with the type of filler. It is known that the filler also affects elastic properties of rubber.

* For references, see end.

- 2 -

Having established the nature of the relationship of α to the filler, it is necessary to compare the elastic properties of rubber with the value of this coefficient.

CONSTITUENTS	COMPOUND NUMBER		
	10	13	17
	PARTS BY WEIGHT		
Rubber	100.0	100.0	100.0
Sulphur	3.0	3.0	3.0
Captax	0.7	0.7	0.7
Zinc oxide	5.0	5.0	5.0
Atomised carbon ...	-	30.0	60.0
VULCANISATION AT 3 ATMOSPHERES, 30 MINUTES			
Coefficient of linear absorption (in cm^{-1})	3.23	3.76	3.95

Computing α from the formula

$$\alpha = \frac{8}{3} \pi^2 \frac{\eta}{\rho v_0^3} \nu^2,$$

where η is the coefficient of internal friction

ν is the frequency of the ultrasonic vibrations

ρ is the density

v_0 is the velocity of propagation of the ultrasonic vibrations in the material taking

$$\eta = 264 \text{ poises [11]}$$

having measured the velocity, [9]

$$v_0 = 2650 \text{ m per sec.}$$

and density $\rho = 1.25$ grams per cubic centimetre, we get

$$\alpha \approx 3 \text{ cm}^{-1}$$

which agrees with the experimental data.

It is known that the vulcanisation of rubber produces crystallisation, which affects its physical properties. In this connection it is of interest to determine the relationship between the absorption and the method of vulcanisation.

The relationship between the coefficient of linear absorption for compound No. 17 and the vulcanisation process is represented on Figure 1. The values of α in centimetres^{-1} are plotted along the ordinate axis, the time of vulcanisation in minutes along the abscissae.

Figure 2 shows the relationship of the coefficient of linear absorption to the extension of the rubber specimen (mixture No. 10). The values of α in centimetres^{-1} , are plotted along the ordinate axis and the relative percentage extension along the abscissae.

As may be seen from Figure 2, α within the experimental limits varies linearly with the amount of distortion which produces an alteration in the arrangement of the molecular chains.

An investigation of the wide field opened up by the determination of the relationships described in the present work is a task for future research.

- 3 -

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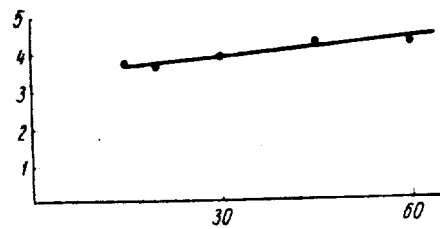


Fig. 1

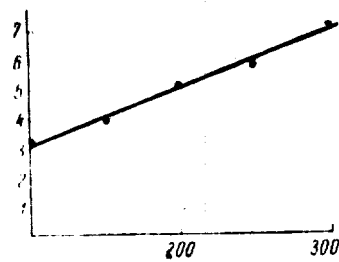


Fig. 2